

Sm-Nd, Rb-Sr, and Mn-Cr Ages of Yamato 74013. L. E. Nyquist¹, C.-Y. Shih², and Y. D. Reese³, ¹Mail Code KR, NASA Johnson Space Center, Houston, TX 77058-3696, USA, laurence.e.nyquist@nasa.gov, ²Mail Code JE-23, ESCG/Jacobs Sverdrup, P.O. Box 58477, Houston, TX 77258-8477, USA, ³Mail Code JE-23, ESCG/Muniz Engineering, Houston, TX 77058, USA.

Introduction:

Yamato 74013 is one of 29 paired diogenites having granoblastic textures [1]. The ³⁹Ar-⁴⁰Ar age of Y-74097 is ~ 1100 Ma [2]. Rb-Sr and Sm-Nd analyses of Y-74013, -74037, -74097, and -74136 suggested that multiple young metamorphic events disturbed their isotopic systems [3]. Masuda et al. [4] reported that REE abundances were heterogeneous even within the same sample (Y-74010) for sample sizes less than ~2 g. Both they and Nyquist et al. [5] reported data for some samples showing significant LREE enrichment. In addition to its granoblastic texture, Y-74013 is characterized by large, isolated clots of chromite up to 5 mm in diameter [1]. Takeda et al. [1] suggested that these diogenites originally represented a single or very small number of coarse orthopyroxene crystals that were recrystallized by shock processes. They further suggested that initial crystallization may have occurred very early within the deep crust of the HED parent body. Here we report the chronology of Y-74013 as recorded in chronometers based on long-lived ⁸⁷Rb and ¹⁴⁷Sm, intermediate-lived ¹⁴⁶Sm, and short-lived ⁵³Mn.

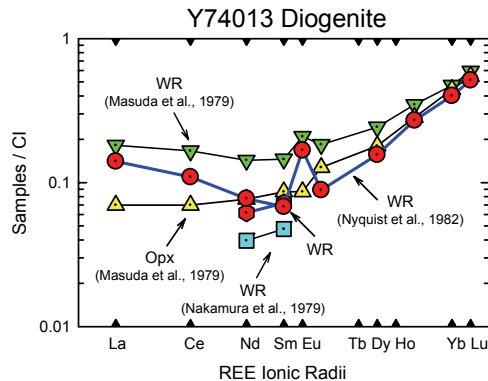


Figure 1. REE abundances in Y-74013.

REE abundances:

REE element abundances for our sample of Y-74013 were determined by mass spectrometric isotope dilution analyses during the earlier investigation [5]. Combined with data from [3] and [4], they illustrate the extent of trace element variability due to sample heterogeneity, and provide a useful context for the isotopic studies (Fig. 1). Comparing the whole rock REE analyses reported by [4] and [5] shows close agreement for Lu, Yb, and Eu abundances, but significant discrepancies for the other REE.

Y-74013 consists almost entirely of opx [6] into which the HREE (Heavy Rare Earth Elements) are strongly partitioned. That opx dominates the abun-

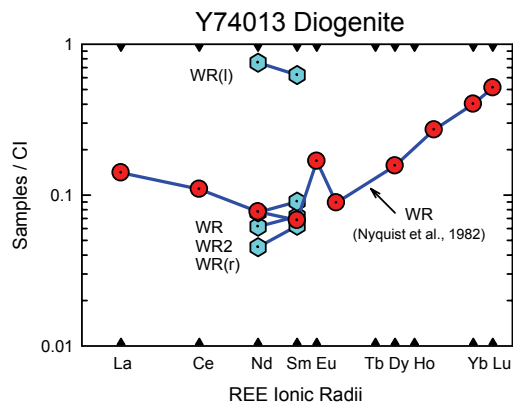


Figure 2. Sm and Nd abundances in separated phases compared to those in a bulk sample [5].

dances of Lu and other HREE in the bulk rock irrespective of variations in the modal abundances of minor mineral components is shown by the good agreement of the HREE abundances in the hand-picked opx sample with those in the bulk samples. Good agreement between the Eu abundances in the Masuda et al. [4] and Nyquist et al. [5] samples shows the two samples contained similar modal abundances of plagioclase, present as a trace constituent. However, the Masuda et al. sample [4] apparently contained a greater proportion of a second trace component with elevated overall REE abundances.

¹⁴⁷Sm-¹⁴³Nd isochron:

Additional bulk samples were analyzed for Sm and Nd abundances as part of the isotopic analyses (Figs 2,3). Measured Sm concentrations in replicate bulk samples (WR, WR2) scatter about that of the earlier WR analysis [5] (Fig. 2), but the Nd concentrations give no indication of the LREE enrichment found earlier. The new analyses are in general agreement with the WR analysis of [3]. These four bulk analyses suggest that the comparatively high

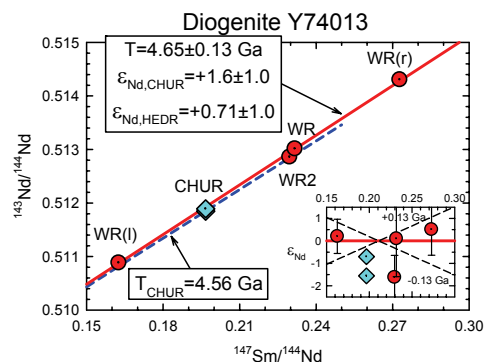


Figure 3. ¹⁴⁷Sm-¹⁴³Nd isochron for Y-74013.

REE abundances reported by [4] were atypical, due to an atypically high modal abundance of a leachable phase present in the leachate WR(l) and tentatively identified with phosphates. WR(l) appears initially to have been in isotopic equilibrium with opx, represented essentially by the residue after leaching, i.e., WR(r) (Fig. 3). These two phases determine an isochron for an age $T = 4.65 \pm 0.13$ Ga and initial $\epsilon_{\text{Nd,HEDR}} = +0.71 \pm 1.0$ relative to the HED reservoir value (HEDR) determined for eucrites earlier [7].

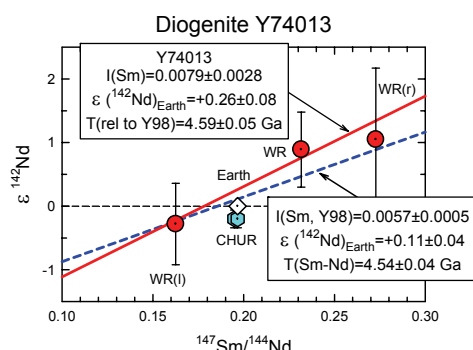


Figure 4. ^{146}Sm - ^{142}Nd isochron for Y-74013.

^{146}Sm - ^{142}Nd isochron:

The $^{142}\text{Nd}/^{144}\text{Nd}$ data are relatively imprecise due to the small quantities of Nd available for analysis. Nevertheless, the ^{146}Sm - ^{142}Nd data confirm an ancient age for Y-74013, giving a value of 4.59 ± 0.05 Ga relative to the age of 4.54 ± 0.04 Ga [8] for cumulate eucrite Y-980433 (Fig. 4).

Rb-Sr Data:

The Rb-Sr data show significant isotopic resetting (Fig. 5). The residues after leaching of a bulk sample and separated orthopyroxene, WR(r) and Opx(r), respectively, lie on a reference isochron deter-

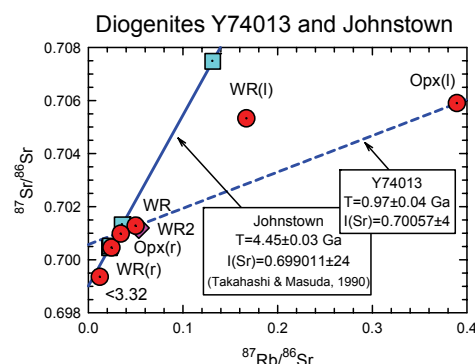


Figure 5. Rb-Sr isotopic data for Y-74013 compared to that of Johnstown [9]. The Johnstown age has been adjusted to $\lambda(^{87}\text{Rb}) = 0.01402 \text{ Ga}^{-1}$.

mined for the Johnstown diogenite [9], but the leachates WR(l) and Opx(l), respectively, are displaced towards higher Rb/Sr ratios. A tie-line between Opx(l) and Opx(r) including the unleached bulk samples WR and WR2 gives an apparent age of 0.94 ± 0.04 Ga, in agreement with the $^{39}\text{Ar}/^{40}\text{Ar}$ age of

~ 1.1 Ga [2]. The sample most enriched in plagioclase (density $< 3.32 \text{ g/cm}^3$) also is slightly displaced from the reference isochron. Apparently, radiogenic $^{40}\text{Ar}^*$ was outgassed from plagioclase, the likely major host of K, ~ 1.1 Ga ago, but the Sr isotopic composition of plagioclase was little affected by this event.

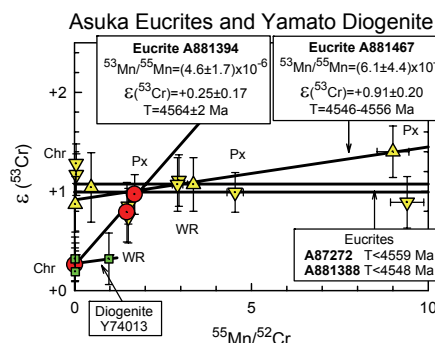


Figure 6. Mn-Cr isochron for Y-74013 compared to those of several eucrites. After [10].

Mn-Cr Isochron:

Cr is strongly enriched over Mn in Y-74013 compared to eucrites (Fig. 6) preventing a precise determination of a Mn-Cr isochron. Measured $^{53}\text{Cr}/^{52}\text{Cr}$ in the Y-74013 chromites is the same as for chromite from the Asuka 881394 unique magnesian “eucrite” [10]. The latter has been dated at 4566.52 ± 0.33 Ma by the $^{207}\text{Pb}/^{206}\text{Pb}$ method [11]. Because of the low $^{55}\text{Mn}/^{52}\text{Cr}$ ratio of the bulk Y-74013 diogenite, we are unable to say whether the chromite formed contemporaneously with crystallization of the whole rock, or later during metamorphism. Nevertheless, our results verify that the diogenite formed during initial differentiation of the HEDPB, and before several eucrites, unless the ^{53}Mn - ^{53}Cr isochrons of the latter were reset ~ 10 Ma after differentiation of the parent body (Fig. 6 and [10]).

Conclusions: Our results confirm that the Y-74013-type granoblastic diogenites formed very early in solar system history. Their relationship to the apparently younger diogenites Tatahouine and Johnstown [9] is unclear, and is perhaps further evidence of a multiplicity of HED-like differentiated parent bodies within the early solar system, including apparently a separate parent body for A-881394 [12].

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